World Geomorphological Landscapes

Gonçalo Vieira
José Luís Zêzere
Carla Mora *Editors*

Landscapes and Landforms of Portugal

Springer

Editors
Gonçalo Vieira
Centre of Geographical Studies
Institute of Geography and Spatial Planning
University of Lisbon
Lisbon, Portugal

José Luís Zêzere
Centre of Geographical Studies
Institute of Geography and Spatial Planning
University of Lisbon
Lisbon, Portugal

Carla Mora
Centre of Geographical Studies
Institute of Geography and Spatial Planning
University of Lisbon
Lisbon, Portugal

ISSN 2213-2090 ISSN 2213-2104 (electronic)
World Geomorphological Landscapes
ISBN 978-3-319-03640-3 ISBN 978-3-319-03641-0 (eBook)
https://doi.org/10.1007/978-3-319-03641-0

This Springer imprint is published by the registered company Springer Nature Switzerland AG
The registered company address is: Gewerbestrasse 11, 6330 Cham, Switzerland

Geoconservation in Portugal with Emphasis on the Geomorphological Heritage

24

José Brilha and Paulo Pereira

Abstract

Geoconservation in Portugal has been gaining importance, particularly during the last decade. The inventory of geosites with international and national scientific relevance is now complete, and the national legislation concerning nature conservation includes the management of geoheritage. Forty-three per cent of the inventoried geosites are geomorphosites, showing the importance of this type of geological heritage in the Portuguese natural heritage. The geoscientific community is slowly recognizing geoconservation as an emergent component of the geosciences. The existence of four UNESCO Global Geoparks in Portugal is also an example of the country's involvement in the international geoconservation scene.

Keywords

Geoconservation • Geoheritage • Geomorphological heritage • Inventory • Portugal

24.1 Introduction

It is getting more and more evident that the increase of human population and the consequent demand for natural resources, the growth of big cities with the arrival of people coming from the countryside, and the land occupation with the multiplication of infrastructures are pressing nature to an extent without parallel in history. The impacts on nature are still being assessed as more research is being produced all over the world, but typically, societies are more aware of the impacts on biodiversity and consequently, in most of countries protected areas were implemented in order to preserve sensitive ecosystems. Only recently, geoscientists began to alert also about the impacts on geodiversity, but people are still not very convinced that rocks, fossils, and landforms need to be preserved!

Threats to geodiversity are poorly known by a society that ignores the role of geodiversity and how its values are highly relevant for humans (Gray 2013; Brilha et al. 2018). Obviously, we cannot protect all geodiversity as we need to consume huge amounts of geological resources to maintain our living standards. This assumption constitutes the main reason why we need to identify and select localities with exceptional geodiversity values, the preservation of which guarantees a sustainable scientific, educational, and touristic use of these natural elements.

The exceptional elements of geodiversity with scientific value can occur in situ, as geosites, or can be stored ex situ in museum collections, as geoheritage elements (Brilha 2016). When geomorphological aspects are the main justification to select a geosite, it can be also named geomorphosite, following the adoption of the International Association of Geomorphologists. The collection of geosites that occur in a particular area (a park, a municipality, a country, etc.) constitutes the geological heritage of that area. Geological heritage should be understood as a general reference to all geosites that include all types of geodiversity elements, such as landforms, fossils, minerals, rocks or soils, among others. The term "geomorphological heritage" refers to geosites with geomorphological significance (geomorphosites). Recently, Brilha (2016) has proposed that sites which have no scientific relevance but present educational, aesthetic, or cultural value should be named as geodiversity sites.

Geoconservation is an emergent branch of the geosciences aiming at the conservation of any type of geological feature that has a particular value (scientific, educational, cultural, aesthetic, etc.). Henriques et al. (2011) discussed

J. Brilha (✉) · P. Pereira
Institute of Earth Sciences, Pole of the University of Minho, Braga, Portugal
e-mail: jbrilha@dct.uminho.pt

P. Pereira
e-mail: paolo@dct.uminho.pt

G. Vieira et al. (eds.), *Landscapes and Landforms of Portugal*, World Geomorphological Landscapes,
https://doi.org/10.1007/978-3-319-03641-0_24

the theoretical bases to consider geoconservation as a part of geoscience with three scopes: basic, applied, and technical applications of geoconservation. Geoconservation aims at the proper management of sites, including all stages, starting with an inventory and assessment of sites, followed by their protection and definition of conditions to guarantee a sustainable use, and finally, periodic monitoring of its preservation.

Considering public policies, geoconservation is closely related to nature conservation and land-use planning. Geoheritage corresponds to the abiotic sector of the natural heritage, despite the major conservation actions still being focused on the preservation of biodiversity. For over 60 years of activity, the International Union of Conservation of Nature (IUCN) has been promoting almost exclusively biodiversity. It was only recently that IUCN showed a slow change in this perspective, recognizing the importance of geoheritage in nature conservation. In 2008, 2012, and 2016, the IUCN has approved resolutions stressing the importance of geodiversity and the need to protect geoheritage. A new handbook about protected areas and management published under the auspices of the IUCN includes, for the first time, a chapter dedicated to geoconservation (Crofts et al. 2015). This chapter is one of the first outcomes of the Geoheritage Specialist Group, created in 2013 under the IUCN World Commission on Protected Areas. This evolution in the IUCN perspective is significant and can bring changes in nature conservation policies at the international and national levels.

The existence of geosites and geodiversity sites must be considered in land-use planning and in environmental impact assessment procedures (Reynard and Brilha 2018). The need to conserve these places and the consequent set-up of management procedures may imply restrictions in the normal use of the territory. For instance, the protection of a site may justify changes in the initial plans for new infrastructure such as roads, dams, and buildings. During the environmental impact assessment of a certain project, the occurrence of sites in the area and the possible effects on them should also be considered in the final evaluation.

24.2 Legal Setting and Geosites Management in Portugal

The protection of geoheritage in Portugal is supported by national legislation related to nature conservation (Brilha 2010). The Decree 142/2008 defined, for the first time in the national legislation, the concept of geosite and geological heritage. Protected areas can be created and managed taking into account the geological heritage and penalties that can be applied to anyone who damages geosites located inside protected areas. Although not focused on geodiversity, there is other legislation that might contribute indirectly to geoconservation: the law for the Protection of Cultural Heritage (which includes the palaeontological record as cultural heritage), the European Landscape Convention, the Natura 2000 Network, and the National Ecological Reserve.

The "Institute of Conservation of Nature and Forests" (ICNF) is the official body responsible for the management of protected areas. The national system of protected areas is composed of 44 areas belonging to different categories (national and natural parks, natural reserves, natural monuments, and protected landscapes). The Azores and Madeira archipelagos have another set of protected areas in accordance with the regional legislation of these two autonomous regions. There are geosites of national significance located inside many protected areas, and there are even some protected areas that were established based on the occurrence of a particular geosite. In mainland Portugal, all natural monuments gained statutory protection due to the need to protect geological features. These are dinosaur footprints of the Ourém, Carenque, Lagosteiros, Pedra da Mua, and Pedreira do Avelino Natural Monuments, the Jurassic sedimentary record of worldwide significance for the Cabo Mondego Natural Monument, and the quartzite ridges of the Portas de Ródão Natural Monument. The latter was designated in 2009 mainly due to its geomorphological assets. The Protected Landscape of the Fossil Cliff of Costa da Caparica was created in 1984 taking into account the protection of geomorphological features, like some other local protected areas. In the Azores, the majority of geosites is inside 123 protected areas scattered across the nine islands of the archipelago and managed by the regional natural conservation body. In Madeira, the limited number of protected areas (6) does not cover the majority of geosites of the archipelago.

Like in many other countries, geoparks are being implemented in Portugal and promote geoconservation, in spite of the informal character of this type of territorial management. In Portugal, presently there are four UNESCO Global Geoparks: the Naturtejo Geopark (since 2006) enclosing the municipalities of Castelo Branco, Idanha-a-Nova, Nisa, Penamacor, Proença-a-Nova, Oleiros, and Vila Velha de Ródão; the Arouca Geopark (since 2009) corresponding to the area of this municipality; the Azores Geopark (since 2013), which integrates the nine islands of the archipelago; and the Terras de Cavaleiros Geopark (since 2014), corresponding to the area of Macedo de Cavaleiros municipality. The geomorphological heritage of these geoparks is a major asset responsible to attract geotourists and to promote local development.

24.3 The National Inventory of Geoheritage

The initiatives in Portugal towards the protection of geoheritage started at the beginning of the twentieth century, but these were mainly local actions and limited in time (Brilha 2005; 2012; Brilha and Galopim de Carvalho 2010). It was only in the end of the 1980s that more comprehensive actions were implemented, which helped to raise awareness for the need to execute an effective geoconservation.

Concerning the national inventory of geoheritage, it was only in 2012 that a systematic and truly nationwide endeavour was concluded. For five years, the University of Minho coordinated a research project with other Portuguese partner universities (Aveiro, Açores, Algarve, Coimbra, Évora, Lisboa, Madeira, Nova de Lisboa, Porto, and Trás-os-Montes e Alto Douro), in order to define a national geoconservation strategy (Brilha et al. 2008). This project has produced several outputs, namely

i. An inventory of geosites of scientific value with national and international relevance,
ii. An online database of the national geoheritage inventory (available at http://geossitios.progeo.pt),
iii. Legislative proposals about geoconservation,
iv. A selection of the most important Portuguese geosites and submission to national authorities, requesting their official designation and integration in the national network of protected areas,
v. Scientific cooperation between Portuguese and Spanish geoconservationists for the identification of geosites with Iberian relevance,
vi. An outreach book addressed to the general public (Brilha and Pereira 2012).

The national geosite inventory followed the method proposed by The European Association for the Conservation of the Geological Heritage (ProGEO) and applied in several European countries (Wimbledon 1996; Wimbledon et al. 1999). Twenty-seven geological frameworks were defined (Table 24.1), and 325 representative geosites were selected and assessed for their scientific value, representing a national endeavour carried out voluntarily by 70 geoscientists (Brilha et al. 2010). Geosites were selected using the following criteria: representativeness, rareness, diversity of geodiversity elements, integrity, and scientific knowledge. The final list of geosites is now included in the national database of natural heritage, under ICNF responsibility.

The risk of degradation of all geosites was quantitatively evaluated using the following criteria: natural fragility of geodiversity elements, proximity to potential threatening activities, present protection status, accessibility, and population density.

Despite being the most complete inventory made in Portugal so far, it is obvious that such an inventory is never closed. New geosites may be included in the future as scientific knowledge develops.

24.4 Geomorphological Heritage

The national inventory of geoheritage includes 140 geomorphosites, occurring in seven of the 27 frameworks (Fig. 24.1 and Table 24.2) (Pereira et al. 2013, 2015). Figure 24.2 shows selected examples of Portuguese geomorphosites in different settings.

The inventoried geomorphosites are heterogeneous in scale, varying from isolated landforms with a few square

Table 24.1 Geological frameworks defined in Portugal to integrate the inventory of geosites with scientific value

• Neoproterozoic-Cambrian Metasediments in Central Iberian Zone • Palaeozoic Marbles of the Ossa-Morena Zone • Ordovician of Central Iberian Zone • Palaeozoic succession of the Barrancos region • Exotic Terranes of NE Portugal • Geotraverse of the Portuguese Variscan Fold Belt • Geology and metallogenesis of Iberian Pyrite Belt • Marine Carboniferous of the South Portuguese Zone • Continental Carboniferous • Pre-Mesozoic granitoids • The Iberian W-Sn Metallogenic Province • Gold mineralization in Northern Portugal • Meso-Cenozoic tectonic evolution of the western Iberian Margin	• Late Triassic of SW Iberia • Jurassic record in the Lusitanian Basin • Cretaceous rocks of the Lusitanian Basin • Dinosaur footprints of western Iberia • Meso-Cenozoic tectono-stratigraphy of the Algarve • Cenozoic basins of the western Iberian Margin • Landforms and river network of the Portuguese Iberian Massif • Karst systems of Portugal • Active and fossil coastal cliffs • Low coasts • Neotectonics in mainland Portugal • Vestiges of Pleistocene glaciations • Volcanism of The Azores Archipelago • Volcanism of The Madeira Archipelago

Geoscientists have identified representative geosites for each framework in a total of 325 geosites

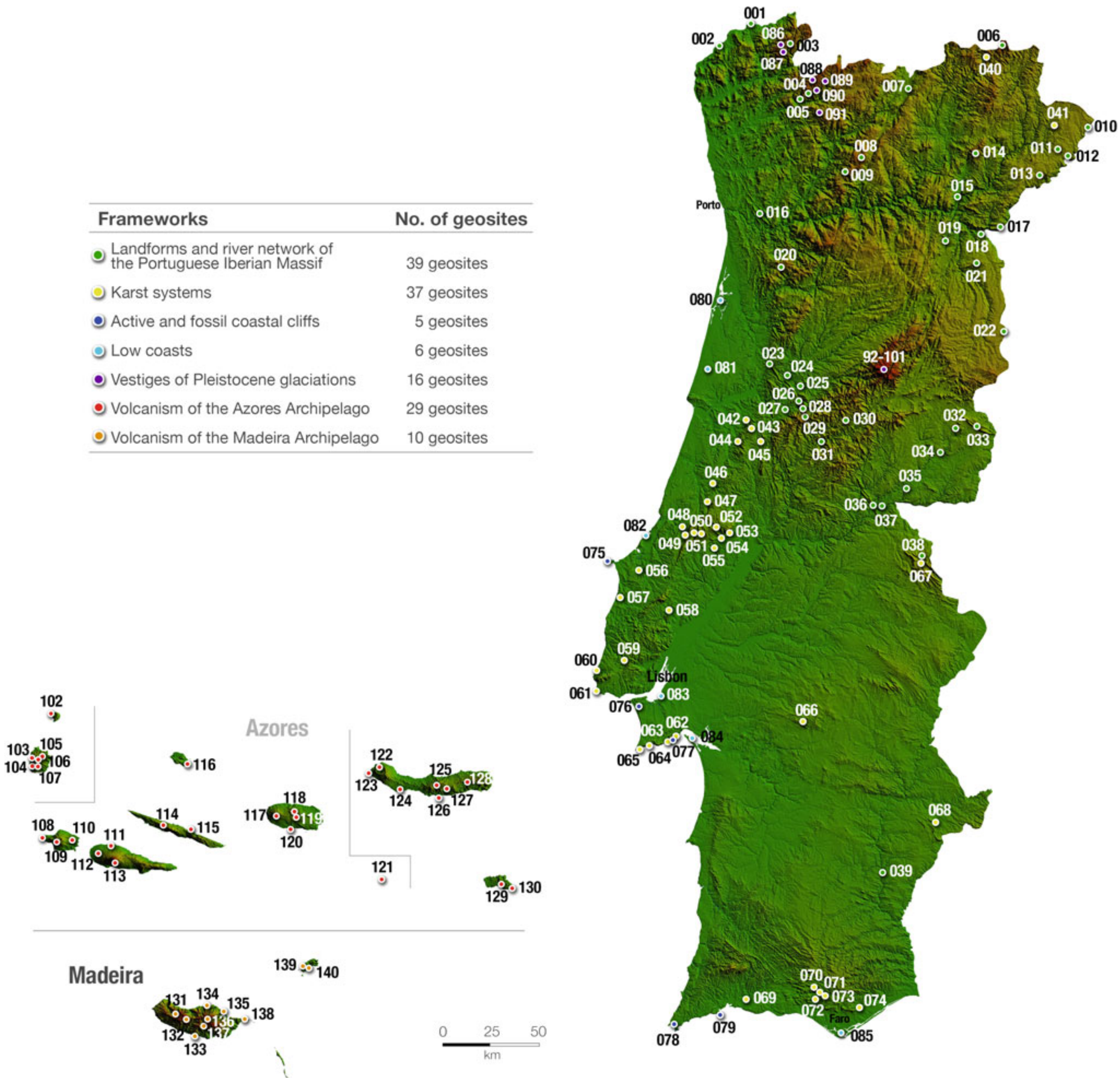

Fig. 24.1 Distribution of the 140 geomorphosites in Portugal, grouped by seven of the 27 geological frameworks. The numbers are the same for Table 24.2

metres in area to large-scale landforms occupying several hundred square kilometres. Large-scale geosites constitute serious management challenges. The definition of the perimeter, a fundamental step for the management of any geosite, needs to be established with parsimony and objective criteria in order to avoid huge areas and consequent difficulties to guarantee proper management.

In spite of many geomorphosites being included in protected areas, their conservation and management are not automatically assured. A geoconservation action plan must be designed and implemented for all geosites with high scientific value, a task under the responsibility of park managers, according to the Portuguese legislation.

Usually, geomorphological heritage shows high potential to be used as tourist attractions due to aesthetic reasons. Many geosites listed in Table 24.2 are already traditional touristic destinations in Portugal, but the general public is not aware that it is visiting a geomorphosite. Hence, geosite

Table 24.2 List of the 140 geomorphosites grouped in seven geological frameworks. The numbers are the same for Fig. 24.1

Landforms and river network of the Portuguese Iberian Massif
001. Cortes terrace
002. Campo terraces
003. Penameda bornhardt
004. Rocalva bornhardt
005. Gerês tectonic valley
006. Cheira da Noiva granite landforms
007. Vilar de Nantes deposits
008. Minhéu viewpoint
009. Fisgas do Ermelo waterfall
010. S.João das Arribas viewpoint
011. Atenor deposits
012. Fraga do Puio viewpoint
013. Faia da Água Alta waterfall
014. Bornes pop-up mountain
015. Vilariça tectonic basin
016. Senhora do Salto crest
017. Poiares sincline
018. Barca d'Alva terraces
019. Longroiva tectonic basin
020. Frecha da Mizarela waterfall
021. Marofa crest
022. Nave de Haver deposits
023. S. Pedro Dias crest
024. Alva meanders
025. Picadouro deposits
026. Sra. da Candosa valley
027. Lousã tectonic basin
028. Sacões hill
029. Penedos de Góis crest
030. Sta. Luzia crest
031. Zêzere meanders
032. Monsanto Inselberg
033. Penha Garcia crest
034. Ponsul Fault scarp
035. Medronheira valley
036. Portas de Ródão crest
037. Rodão terraces
038. Marvão crest
039. Pulo do Lobo waterfall
Karst systems
040. Lorga de Dine cave

(continued)

Table 24.2 (continued)

041. Santo Adrião caves
042. Condeixa tufa deposits
043. Buracas do Casmilo
044. Anços springs and Poios valleys
045. Ateanha-Dueça transverse
046. Lapedo valley
047. Grota valley and Lis springs
048. Vale do Mogo springs and caves
049. Candeeiros fossil sea cliff
050. Fonte da Bica–Porto de Mós diapiric valley
051. Mendiga and S. Bento karst landscape
052. Alvados–Minde transpressive lane
053. Almonda cave
054. Arrife fault scarp
055. Olhos de Água do Alviela springs
056. Óbidos–Caldas da Rainha diapiric valley
057. Maceira diapiric valley
058. Ota canyon
059. Granja dos Serrões and Negrais karrenfelds
060. Adraga and Pedra d'Alvidrar caves
061. Karren and caves of Raso cape
062. Creiro crevice caves
063. St. Margarida and Figueira Brava caves
064. Frade cave
065. Forte da Baralha wave-cut platform
066. Escoural cave
067. Cova da Moura cave
068. Fossil karren and karst caves of Preguiça mines
069. Estombar springs and Ibne Ammar cave
070. Rocha da Pena mesa hill
071. Nave do Barão and Nave dos Cordeiros depressions
072. Varejota and Barrocal da Tôr karrenfelds
073. Fonte Benémola spring and Solustreiras caves
074. Cerro da Cabeça karrenfeld
Active and fossil coastal cliffs
075. Carvoeiro cape cliffs
076. Costa da Caparica fossil cliff
077. Serra do Risco cliff
078. S. Vicente–Sagres coastal platform
079. Ponta da Piedade cliffs
Low coasts
080. Aveiro Ria
081. Mira–Quiaios dunes

(continued)

Table 24.2 (continued)

082. S. Martinho do Porto bay
083. Tejo estuary
084. Sado estuary and Troia spit
085. Ria Formosa
Vestiges of Pleistocene glaciations
086. Alto Vez valley
087. Gorbelas–Junqueira
088. Homem valley
089. Compadre valley
090. Couce plateau
091. Toco–Soutinho
092. Lagoacho–Covão do Urso
093. Nave Travessa
094. Lagoa Comprida plateau
095. Covões de Loriga
096. Salgadeiras
097. Zêzere valley
098. Lagoa Seca
099. Covão Cimeiro-Cântaro Magro
100. Nave de Santo António
101. Pedrice
Volcanism of the Azores Archipelago
102. Caldeirão
103. Fajã Grande and Fajãzinha
104. Rocha dos Bordões and volcanic necks
105. Pico da Sé and volcanic necks
106. Funda, Comprida, Seca and Branca maars
107. Funda and Rasa maars
108. Capelinhos volcano
109. Faial Caldera
110. Pedro Miguel graben
111. Lajidos de Santa Luzia
112. Torres volcanic cave
113. Pico Mountain
114. Axial volcanic ridge
115. Fajãs dos Cubres and Caldeira de Santo Cristo
116. Graciosa Caldera and Furna do Enxofre
117. Santa Bárbara Volcano and Mistérios Negros
118. Pico Alto, Biscoito da Ferraria and Biscoito Rachado
119. Algar do Carvão
120. Monte Brasil
121. D. João de Castro bank
122. Sete Cidades volcano

(continued)

Table 24.2 (continued)

123. Pico das Camarinhas and Ponta da Ferraria
124. Carvão volcanic cave
125. Fogo volcano
126. Vila Franca islet
127. Congro and Nenúfares maar
128. Furnas volcano
129. Barreiro da Malbusca
130. Ponta do Castelo
Volcanism of the Madeira Archipelago
131. Pico da Selada deposits
132. Pedras
133. Girão cape
134. Arco de São Jorge
135. Ribeira do Faial mouth
136. Caldeirão do Inferno
137. Eira do Serrado
138. São Lourenço cape
139. Ana Ferreira peak
140. Porto Santo beach

managers should consider the implementation of good interpretation resources as a priority, not only to foster the geomorphological literacy, but also to better promote geosites as touristic attractions.

24.5 Conclusion

Geoconservation in Portugal has developed significantly during the last decade, particularly with the development of the national inventory of geosites, the change in legislation supporting nature conservation policies, and the implementation of geoparks. However, the efforts to pursue a geoconservation strategy must continue, mainly focusing on management issues of the most important geosites at the national and international levels.

Acknowledgements A national inventory of geosites is only possible with the participation of geoscientists who are experts in different geoscience domains. All colleagues that participated in the inventory are acknowledged for this truly national effort. This work was co-funded by the European Union through the European Regional Development Fund, based on COMPETE 2020 (Programa Operacional da Competitividade e Internacionalização), project ICT (UID/GEO/04683/2013) with reference POCI-01-0145-FEDER-007690, and national funds provided by Fundação para a Ciência e Tecnologia.

Fig. 24.2 Examples of geomorphosites in Portugal. A. Ria Formosa barrier islands geosite in Ria Formosa Natural Park, south-eastern Portugal. Geological framework: low coasts. Geomorphosite Nr. 85 in Fig. 24.1, B. Coastal cliffs of Ponta da Piedade geosite in south-western Portugal. Geological framework: Active and fossil coastal cliffs. Geomorphosite Nr. 79 in Fig. 24.1, C. Pulo do Lobo waterfall geosite in Vale do Guadiana Natural Park, south-eastern Portugal. Geological framework: landforms and river network of the Portuguese Iberian Massif. Geomorphosite Nr. 39 in Fig. 24.1, D. Lateral moraine at Compadre valley geosite in Peneda-Gerês National Park, north-western Portugal. Geological framework: vestiges of Pleistocene glaciations. Geomorphosite Nr. 89 in Fig. 24.1, E. Furnas volcano caldera geosite in São Miguel Island, Azores. Geological framework: volcanism of the Azores archipelago. Geomorphosite Nr. 128 in Fig. 24.1, F. Coastal landforms in São Lourenço cape geosite in Madeira island. Geological framework: volcanism of Madeira archipelago. Geomorphosite Nr. 138 in Fig. 24.1

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